E/CONF.39/A/44
29 Sept.1962
ORIGINAL : ENGLISH

UNITED NATIONS CONFERENCE
ON THE APPLICATION OF SCIENCE AND TECHNOLOGY
FOR THE BENEFIT OF THE LESS DEVELOPED AREAS

Agenda Item: A.5.2.1

Portugal

APPLICATION OF THE TURAM ELECTROMAGNETIC METHOD TO PYRITE AND COPPER PROSPECTION IN SOUTHERN PORTUGAL

By J.L. GUIMARAES DOS SANTOS
and Fernando Jose DA SILVA,
Mining Engineers
of the Serviço de Fomento Mineiro

Papers have been contributed to the United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas as working papers for that Conference. They are published as presented by the contributors, and the contents and the views expressed are those of the contributors. (See notes overleaf.)

NOTES

1. Papers selected for inclusion in General Sessions will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

2. Papers selected for inclusion in Specialized Sessions will be available at the Conference in only one of the above official languages.

3. Summaries of all papers, as submitted by contributors, will be available at the Conference in the following official languages of the United Nations: English, French, Russian and Spanish.

4. Papers and summaries will not be available for general distribution in advance of the Conference. They will be published in advance in limited quantities only for the use of delegations of participating governments and of other authorized participants. Post-Conference publication and general distribution of the Conference Proceedings will follow United Nations practices as laid down by the United Nations Publications Board.

A.5.2.1 APPLICATION OF THE TURAM ELECTROMAGNETIC METHOD TO PYRITE AND COPPER PROSPECTION IN SOUTHERN PORTUGAL

by

J. L. Guimarães dos Santos
and
Fernando José da Silva
Mining Engineers of the Serviço de Fomento Mineiro

1 - INTRODUCTION

The Serviço de Fomento Mineiro (Mine Development Service) is a department of the Direcção-Geral de Minas e Serviços Geológicos (General Direction of Mines and Geological Survey) that was created with the principal aim of estimating the ore reserves of metropolitan Portugal. In its program pyrite and copper ore prospecting was included.

Pyrite and copper are in fact raw materials vital to modern civilisation. Pyrite is fundamental to sulphur and sulphuric acid manufacture; copper in spite of its present over-production is a metal whose consumption has increased considerably.

Taking in consideration this increase of demand the prospection of new cupriferous areas was activated and more ore was extracted from operating mines. Thus the continuous rise of consumption in the civilized parts of the world and the raising of the standart of living in the less developed ones, should in the future lead to a still more intensive search.

Owing to this, prospecting for new pyrite loads was started by the Serviço de Fomento Mineiro some years ago, sometimes in close collaboration with the mine owners. The development of old copper mines and further copper prospection was also done. Geophysical methods were used, specially the Turam electromagnetic method.

2 - PORTUGUESE PYRITE BELT

It is traditionaly known as the portuguese pyrite belt an area of about 120 km long with a medium width of 20 km that, being part of the Alentejo peneplane, goes from the atlantic coast to the spanish frontier prolonging itself into the neighbouring country.

Its substractum is mostly formed by Devonian and Carboniferous schists, schist-sandstone and schist-graywack series and by many eruptive formations lying in concordance with the sedimentary rocks. As pyrite orebodies are in direct relation with the hypogenic rocks, the mapping of these rocks was considered of the utmost importance and so this work was previously done.

In this area Louzal, Aljustrel and S. Domingos orebodies and three others of less economical importance are known since many years ago, having been discovered, every one of them, by their gossan. The higher consumption of pyrite pointed to an acceleration of the development of known orebodies and to eventual discoveries of new ones, being the Serviço de Fomento Mineiro responsability, part of this campaign. Concrete results could be expected by the application of geophysical methods, geological surveying and mining works taken as a whole. In the zones that were considered to be favorable to the discovery of new orebodies geophysical methods began to be applied.

In view of the high conductivity of the ore, of the experience of this method in similar circunstances and of the rapidity with which the ground can be covered the Turam electromagnetic method was used as reconnaissance method. Electrical resistivity and spontaneous polarization would be used as subsidiary methods.

The 1944-49 campaign was technicaly directed by the swedish campany Aktiebolaget Elektrisk Malmletning (ABEM), owner of the Turam patent. The results of this campaign pointed to the execution of some mining works - mostly drill-holes - to discover the causes of some of the most important anomalies. After these works having been finished by the Serviço de Fomento Mineiro in areas not covered by mining properties, it was concluded that carbonaceous and graphitic schists, sometimes with pyrite impregnations, were responsible for the anomalies found.

Among the electromagnetic anomalies found, a serie of anomalies indicated a small depth conductor between the S. João do Deserto and Algares orebodies, in Aljustrel. As the anomalies were inside a mining property the operating company choosed, as the law permits, to do itself the proposed mining works, discovering in this zone an important pyrite orebody.

The negative results obtained in the other works done to analyse the cause of other anomalies, does not exclude the possibility of existing pyrite orebodies not only in the prospected areas but also, in a general point of view, in the whole pyrite belt.

It is true that the detecting depth of the method is relatively small and that other causes as wide carbonaceous and graphitic schists, and sandstones formations with high humidity percentage, may obliterate eventual pyrite orebodies.

The continuity of the formations, its distance from the surface and its width the greater this influence, changing the characteristics of the electromagnetic anomalies and hindering their interpretation and judicious selection. And near or in the vicinity of these orebodies graphitic schists formations are frequent. Owing to all this, gravimetry and geochemistry are to be used by the Serviço de Fomento Mineiro to study the geological favorable areas where anomalies whose character rends difficult a correct interpretation were found.

Besides those that outcrop in the pyrite belt, other porphyries that change laterally into diorites from Montemor-o-Novo to Serpa are found northwards and seem to be related with the cupreous pyrite orebodies of Caeira and Cabrela. Also southeast of Cercal do Alentejo porphyry formations were mapped, with apparent connections with ferromanganesiferous mineralisations and with orebodies of the B.G.P.C. group that are directly or undirectly related with those mineralisations. It is therefore not a bold assumption if the possibility of existence of eventual orebodies in those zones is admited, furthermore if we consider that some spanish geologists have the opinion that the average width of the pyrite belt is 40 km, as in Spain owing to a greater number of known orebodies, this width is easier to estimate.

a) - Prospected areas and works done in the anomaly zones.

In S. Domingos mine an area of 88 km2 was prospected, 65,726 stations being observed. Most of the anomalies found seem to be related with geological contacts. Anomalies that could be related with orebodies were not detected. Only in the mine of Chança, in the vicinity of some ferriferous outcrops, strong anomalies were found, possibly related with pyrite ore. A 40 m crosscut was opened from the surface, in a zone decidedly related with the anomalies, but only porphyries partly mineralised with pyrite were found, this being a result that did not encourage further work.

Afterwards the operating company did a small experiment with gravimetry in this area but the results seem to follow the topography. Years later the same company started a geophysical campaign in the area of S. Domingos using different methods with geochemistry as reconnaissance method. Anomalies were found again in connection with the electromagnetic anomalies already observed. Some drill-holes were made and pyrite lenticules were cut.

In the zone of Alcaria Ruiva an electromagnetic campaign was carried out in 1950 by AREM, working for Mason & Barry, operating company of the mine of S. Domingos. An area of 43.2 km2 with 22,838 points of observation was covered. Great interest was not given to the anomalies found since they seemed to reflect the structural conditions of the zone.

In the vicinity of Aljustrel an area of 178 km with 192,482 points was prospected. Mine anomalies were found but only those located in the mangenese mine of Herdade da Barradinha, in Curral dos Cavaleiros and in Cerro do Carrasco were choosen to be investigated by direct methods. Drill-holes opened in the first two zones were negative. In the Cerro do Carrasco area, in the S. João do Deserto, and in Algares and near the former in a schist lenticule inside the porphyric formation a very strong anomaly was found. On the Serviço de Fomento Mineiro indications, the property owner opened a shaft in the zone that was completely devoid of surface signs. This shaft went through pyrite at a depth of about 14 meters and arrived at the footwall of the orebody at the depth of 32 m. The load was prospected at this level by galeries and rises these being located in profiles with anomalies, and an orebody with an aproximate length of 100 m and with a maximum width of 7 m and an average width 3,6 was exposed. At the same time a drill-hole program was carried out and showed the existence not only of the above mentioned orebody but also of another - Moinho orebody - even greater and in the approximate, direction of the first and also related to it.

After preparatory works the ore proved in this two new orebodies amounted in the beginning of 1962 to 14 million tons. This quantity represents 61 % of the total proved ore of the mine (1).

Upon porphyry outcrops in the region of Castro Verde an area of 220 km2 with 162,027 points was prospected. Most of the many anomalies found, seemed to be related to the geological structure of the zone and among them those that looked more promising were chosen for drilling. The anomalies were due to graphytic and carbonaceous schists.

The region between the mines of Caveira and Louzal was prospected with 108,269 observation points covering an area of 90 km2. In the southeast contact of the porphyry band that lies between those two mines, more developed anomalies were found. The region between the mines of Caveira and Louzal was prospected with 108,269 observation points covering an area of 90 km2. In the southeast contact of the porphyry band that lies between those two mines, more developed anomalies were found. Some drill-holes were made near the Louzal orebody and graphytic and carbonaceous schists were found to be responsible for the electromagnetic variations.

With the intention of studying the zone between Aljustrel and Alcaria Ruiva an E.M. prospection was made in two adjoining bands whose directions were adapted to the geology of the zone. The area covering the village of Albernoa was prospected in 43.2 km2 with 36,482 observed stations. From all the anomalies found a group 300 m in length in the approximate schist-porphyry contact was selected and will be studied later.

In the other band, more to the southeast, an area of 45.3 km with 25,354 observation points was prospected. The small anomalies found seem to reflect geological conditions, such as contacts between different formations.

3 - CUPRIFEROUS ZONES

The copper mines of Alentejo have been known for many years, specially in the regions of Barrancos, Vila Viçosa and Almodovar. Owing to this, the Serviço de Fomento Mineiro decided to begin the study of these mines by stages. Though in a

.....

(1) We should like to take the oportunity to thank the mine owners at Aljustrel for the information so kindly furnished.

first approach of the problem it does not seem possible the use of the E.M. method in this cupriferous orebodies owing to the mineralogical constitution of ore, simple experiments made on samples taken from old tips showed that sometimes there existed continuity in the good conductor minerals in spite of the quartz-carbonate gangue of the ore. It was also known that argilaceous material was present in the dykes and so it was thought possible that the deposit could be a better conductor medium than the adjoining rocks. On the other hand it was known that the frequent presence of graphytic and amplytic schists was inclined to obliterate the indications due to the orebodies that, owing to their smaller mass, would be less high, while the true conditions of carbonaceous schists genesis were not known.

After considering every factor and owing to the fact that geophysical methods when directly applied by the Serviço (2) are not excessively expensive, a trial on a restricted area was decided upon. An area of 10 km2, in the region of Barrancos, was chosen. In this zone copper ores were already known. The data obtained showed that it was worth while to enlarge the area in the same region and to prospect other zones by using this method.

a) - The zone of Barrancos.

In this zone two bands were prospected. One of them has a surface of 18.5 km2 with 19,896 observed stations. Four series of principal E.M. anomalies were found, one of them more outstanding than the others, having a total length of more than four kilometers and divided into various branches, and being generally characterised by low indications either in the field quotients or in the phase differences. Nevertheless - and in this lies its chief value - every old mine workings are located in close relation with these anomalies. Owing to this, it was concluded that they corresponded to one cupriferous dyke and to its ramifications.

The other three series of E.M. indications are very strong anomalies with irregular contours and follow the direction of the geological structure of the region and seem to correspnnd to contacts between different geological formations.

The other prospected band had an area of 29.0 km2 with 17,423 points. Some very strong anomaly series not only in the field quotients curves but also in the phase differences were found, following the general direction of geological formations. Nevertheless, in some cases, the anomalies follow with precision the alignment of the old mine workings.

From the observations made we may put forward the hypothesis of the occurrence of ores in concordance with the stratification. But, by their aspect, the anomalies must be caused either by strata of graphytic or carbonaceous schists or by a much altered basic rock that outcrops here and there.

Other E.M. surveys were made in limited areas of the zone. In a place called Courelas, where a small cupriferous dyke was known, an area of 0.2 km2 with 216 observed stations was prospected; in the mine of Serra da Botefa an area of 0.6 km2 was covered with 319 observation points; and in the mine of Piorneiras an area of 0,7 km2 was observed, with 360 stations; no interesting anomalies were observed in any of these areas.

b) - Zone of Almodovar.

In an area covering the Porteirinhos, the Misericordia and the Brancanes bands a total surface of circa 37.8 km2 was prospected with 61,354 observation points. Anomalies were found and some of them were selected for future study on account of their amplitude, their situation near or in alignment with known orebodies and by being found near the schist-porphyry contact, good for mineral deposition. From all the anomalies, a group of small anomalies stand out due to the fact that they are near a big dyke of quartz with cupriferous mineralizations upon which some

.....

(2) In the 1944-49 campaign the cost per point was Esc. 11.45 while in the campaigns made since 1955 up to now, directly executed by the Serviço de Fomento Mineiro, was only of Esc. 3.60.

claims had been staked. It seems that it follows a fracture and its ramifications in which the quartz dyke is to be found.

If in some cases but not rarely, the small E.M. anomalies are low and not very clear, in other cases are very evident.

In the prospected structure with an average direction of true N 30º W and with the approximate length of 5,500 m, as can be concluded by the geological survey, there is a rejection of over 300 m. The eastern part seems to have been moved southwards, in relation to the other part.

In the middle of the porphyric formation three series of anomalies were found, with the average direction of true N 55º W, related with prospecting works for barytes. These series of E.M. indications are small but evident anomalies related with barytes mineralized dykes.

Other E.M. surveys were made in areas where the existence of cupriferous mineralizations were known; the results are given in the following notes:

In the Barrigão zone, covering three old mine properties, an E.M. survey was made over an area of 12 km2 with 12,568 points; in the zone of the mine Barranco do Vale Cova - Herdade dos Zefetos an area of 3,6 km2 with 8,422 observation points was surveyed; in the areas of the mines Ventosa - Ferraria, Moinho da Romba and Corrego da Vinha 1.5 km2, 1.8 km2 and 1.8 km2 were surveyed with the observations of respectively 1,464, 1,757 and 1,825 observation points. Some small anomalies were found and some of them shall be submitted to future study.

c) - Zone of Montemor-o-Novo.

An E.M. survey made in an area of 12.5 km2 covering the copper mines of Caeira, Cufenos, Courelinha, Carapinha and Grou with 18,685 observation points.

In the zone of the Caeira mine small anomalies were found over a pyrite dyke, known for a length of 110 m, down to the depth of 50 m and with width of 3 m. E.M. indications followed approximatly the direction of the stratification exactly in alignment with the known dyke to both sides of the known zone.

An area of 27.7 km2 with 33,796 observation points was surveyed covering the copper mines of Caeirinha, Herdade do Paço and Herdade do Corte Pereiro. Among the anomalies found a series of anomalies of medium intensity are to be noted coinciding perfectly with the old mine workings alignment.

Other E.M. surveys were made using the Turam in small zones over ore deposits of copper, galena, barytes, arsenopyrite and antimonite.

The surveys for copper ores covered a total area of 15.5 km2 with 19,166 observation points. Only in one of the areas were anomalies obtained over quartz dykes, one of them with traces of old workings with cupriferous minerals in its tips.

Over mines of other ores the E.M. experiments covered a total area of 18.7 km2 with 29,207 observations points. Some anomalies were found over the deposits with extensions beyond the known zones. Some of these anomalies are being studied.

d) - Zone of Cercal-Odemira.

A Turam E.M. survey was made in an area of 4 km2 over dykes of the B.C.P.C. type with 8,256 observation points. A series of anomalies in the porphyry, that stands out from others found, is exactly over a recently discovered dyke. On the other hand anomalies were not found over other known sometimes relatively thick dykes.

e) - Zone of Santo Aleixo da Restauração.

In this zone an area of 9.7 km2 with 10,283 observed stations was surveyed. Some anomalies were found but they seem to have no interest.

4 - FINAL CONCLUSIONS

The problem of the discovery of orebodies in developed countries is a very com

In the case of the iron pyrites orebodies of Portugal the application of the Turam E.M. method was made in the hope of contributing to the solution of this problem and eventually obtaining some positive results. If this has been in some way achieved the matter cannot be considered completely closed. Only in one case was there complete success and that was the discovery of the Cerro do Carrasco orebody which led to the discovery of another orebody of still greater importance - the Moinho orebody.

If we take the discovered reserves into consideration the cost of the whole campaign adds very little to the cost of the tons to be mined out. Cases like this must, however, be considered an exception. We must expect the orebodies to exist at a greater depth without causing electromagnetic variations clear, strong and of easy interpretation.

Due to the many origins of the anomalies - contacts of different conductivity formations, mineral concentrations, strata of graphytic schists, zones of meteoric water-flow favoring electrolitic flow, etc, - the failures will be many though one good result may pay for years of geophysical study.

Generally it is not easy to distinguish the origin of the anomalies and so the use of different geophysical methods based on different properties must be decided upon, to raise the indeterminations. Unfortunately those properties are not exclusive to the ores. Graphytic schists are good conductors and are subject also to high spontaneous polarization; basic rocks have a comparatively high gravity and granites, metamorphic rocks and consolidated sediments from the first geological eras show frequently a high speed of seismic wave propagation. In this lies the interest of the use of different methods and if we analyse the information as a whole then we may with greater assurance recommend mine workings or drill-holes whose cost is higher than the geophysical surveys. This is why the Serviço de Fomento Mineiro has on its program the covering of anomalous areas with geochemical and gravimetric surveys.

August, 1962

BIBLIOGRAPHY

Gomes, A. A. Rocha & Silva, F. J. da, Prospecção de Pirites no Baixo Alentejo, fasc. 1-2 from vol. X of "Estudos, Notas e Trabalhos" do Serviço de Fomento Mineiro, 37-73, Porto (1955).

Gomes, A. A. Rocha & Barros, J. J. de Oliveira, Prospecção e Pesquisa de Filões Cupríferos na Região de Barrancos, Serviço de Fomento Mineiro, (1956). Not printed.

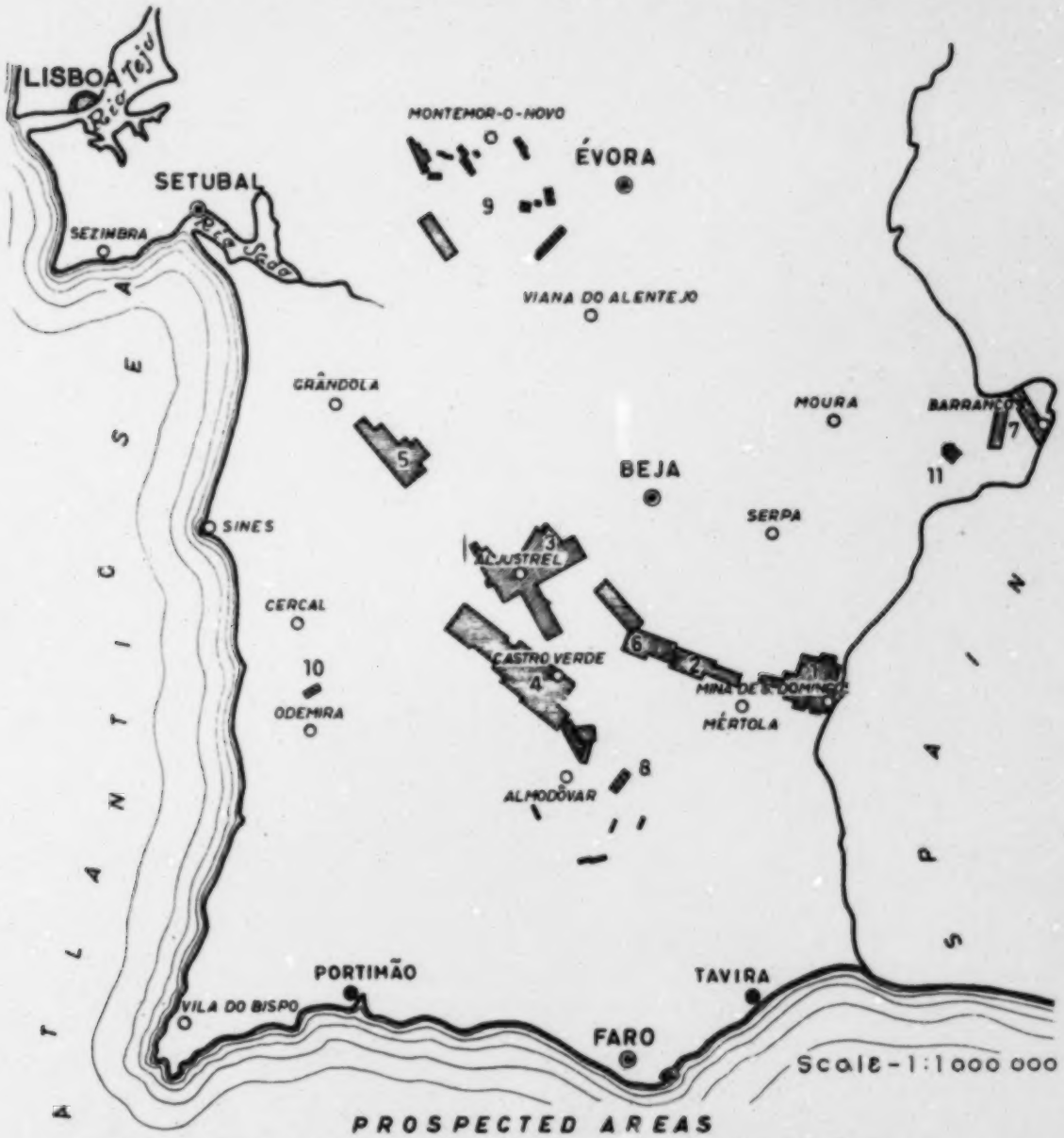
Silva, F. J. da & Gaspar, O. de Barros, Prospecção Electromagnética na Região de Almodôvar, Serviço de Fomento Mineiro, (1962). Not printed.

Serviço de Fomento Mineiro, Relatórios anuais da Brigada do Sul relativos aos anos de 1956, 1957, 1958. Not printed.

APPLICATION OF TURAM METHOD FOR PROSPECTING PYRITE AND COPPER DEPOSITS IN SOUTHERN PORTUGAL

BY

J. L. GUIMARÃES DOS SANTOS AND FERNANDO J. DA SILVA



PROSPECTED AREAS

1 – MINA DE S. DOMINGOS
2 – ALCARIA RUIVA
3 – ALJUSTREL
4 – CASTRO VERDE
5 – CAVEIRA-LOUZAL
6 – ALBERNOA
7 – BARRANCOS
8 – ALMODÔVAR
9 – MONTEMOR-O-NOVO
10 – CERCAL-ODEMIRA
11 – S.TO ALEIXO DA RESTAURAÇÃO

331 E - Sept.1962 - 1,600